Quantifying Munitions Constituents Loading Rates at Operational Ranges

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Outline

- Range Environmental Vulnerability Assessment (REVA)
- Munitions Constituents (MC) Deposition
- MC Loading Estimation
- MC Loading Calculator
- Example – Static Fire Familiarization Range
- Future Efforts
- Acknowledgements

Range Environmental Vulnerability Assessment

- Department of Defense Directive (DoDD) 4715.11
  - Ensure long-term viability of operational ranges while protecting human health and environment
- Department of Defense Instruction (DoDI) 4715.14
  - Establishes framework to conduct operational range assessments
  - Determine whether a release or substantial threat of a release of munitions MC has occurred to off-range areas
- Supports the DoD-wide sustainable range initiative
- Maintain range operations to support warfighter mission readiness

REVA Process

- Baseline assessment of environmental conditions on operational ranges and training areas
  - Conceptual site model development
  - Estimation of MC loading
  - Fate and transport modeling for potential MC migration
  - Environmental sampling
    - Conducted if previous results show a potential release

MC Loading Process Design Goals

- Must be defensible
- Must apply to all installations to ensure consistency across the program
- Must account for all types of munitions related training
- Screening level models require MC loading to be calculated for entire history of range usage
- Assumptions based upon documented studies where applicable (e.g., dud rate, low order rates)

Sources of MC

- Low order detonations (incomplete or partial detonations)
- High order detonations
- Unexploded ordnance (corrosion)

- Deposition can occur at:
  - Target area
  - Firing points
  - Dispersed across impact areas

Image from USACE ERDC TR-05-10

Basic MC Loading Assumptions

- Focus on REVA indicator MC
  - TNT, RDX, HMX - main filler in most munitions
  - Perchlorate – propellant and filler in grenades, rockets, illumination rounds
  - Lead – primary constituent of small arms ammunition
- MC loading estimated for the entire time the range was active
- Loading areas based upon discussions with range control, GIS/mapping data and target locations
  - Highly installation- and range-specific
  - Generally more defined than range surface danger zone
- Actual expenditure data preferred (where available)

MC Loading Rate Inputs

Munition-Dependent Inputs:

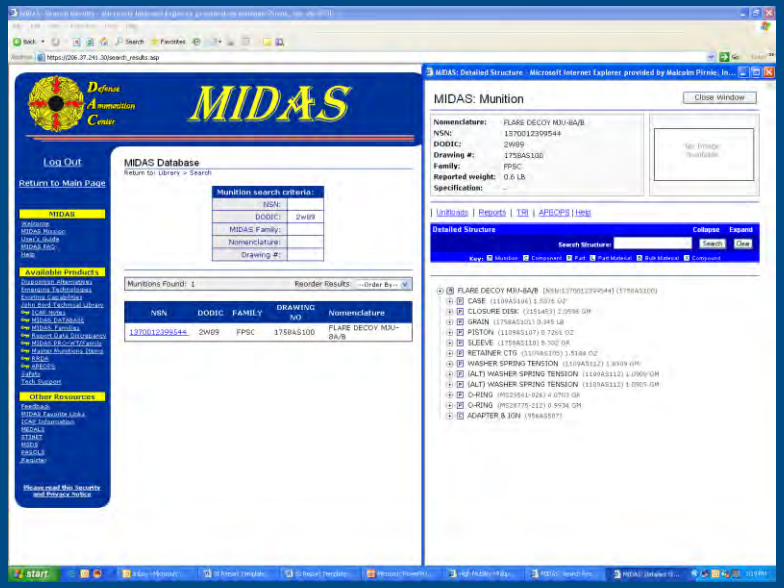
- ***MC Weight***
- ***Dud/Low Order Rates***
  - *Percent of low order, high order and UXO*
  - *Percent of MC deposited on ranges from low and high order detonations and UXO*
- ***Quantities Used***
  - *Actual data (Range Usage Reports, TRI Data, etc.)*
  - *Extrapolation methods (Training Analysis Method, Training Allowance Extrapolation)*
  - *Average training levels throughout history*

Range–Specific Inputs:

- ***Time Period of Use***
- ***Locations (as changed over time)***
- ***Only Affected Area***
  - *Best estimate of area where majority of items impact*

Munitions Data – Net Weight MC per item

Use expenditure data, EOD data and / or range regulations to get list of munition types



Amount of HMX, RDX, TNT, perchlorate, and lead per item

Challenges with MIDAS – not a comprehensive database (many items not available), evolving database, controlled access (Army Defense Ammo Center).

Munitions not in MIDAS are researched in ordnance technical manuals and publications.

Dud and Low Order Rates / MC Remaining

- MC (low-order) = (# Military Munitions expended) x (low order rate*) x (amount of residual remaining from a low order)
  - Similar approach for high order detonations

- MC (UXO) = (Number of Military Munitions expended) x (dud rate*) x (amount of residual exposed as a result of damage to UXO casings)

- MC Remaining
  - Low order = 50%
  - High order = 0.1%
  - UXO = 1%

** Report of Findings for Study of Ammunition Dud and Low Order Detonation Rates, U.S. Army Defense Ammunition Center, July 2000.*

Estimating Total Munitions Use

- Actual expenditure data preferred
- If actual data is unavailable use, one of the REVA developed methods is used to develop baseline value
  - Training analysis method
    - Based upon authorized weapons and range setup
    - Many assumptions required
  - Training allowance extrapolation
    - Based upon yearly training allowance munitions allocations across the Marine Corps (i.e. Non Combat Expenditure Allowance [NCEA] Data)
    - Assumes a percentage of those munitions are used on that range

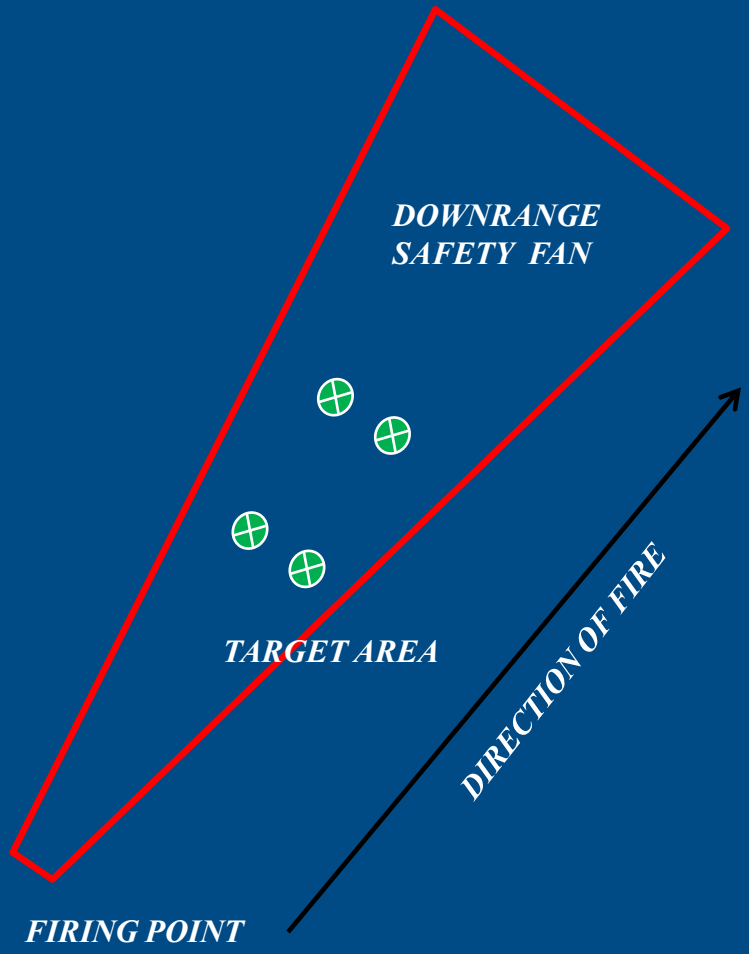
MC Loading Calculator

- Spreadsheet designed to automate equations
- Applies dud, low order, high order rates
- Applies amount of residual remaining for dud, low, and high order
- Applies area calculations
- Built in process to estimate loading for time periods where expenditure data does not exist (data gaps)
- Provides average annual surface load rate (kg/m^2) for each time period

Example – Static Fire Familiarization Range

Range Summary

- Operational from 1977 to present day
  - Early use of range (training types, munitions used) are unknown
- Authorized weapons:
  - Small arms (9 mm, .45 cal M882, 5.56 mm M885, 7.62 mm M118, 12-gage SLG)
  - MK-19, M203, SMAW, AT4, LAW, 60 mm, and 81 mm mortar
- 1.92 x 10^5 square meters (~ 47 acres)



MC Loading Calculator

Place holder – bring up example of completed excel File

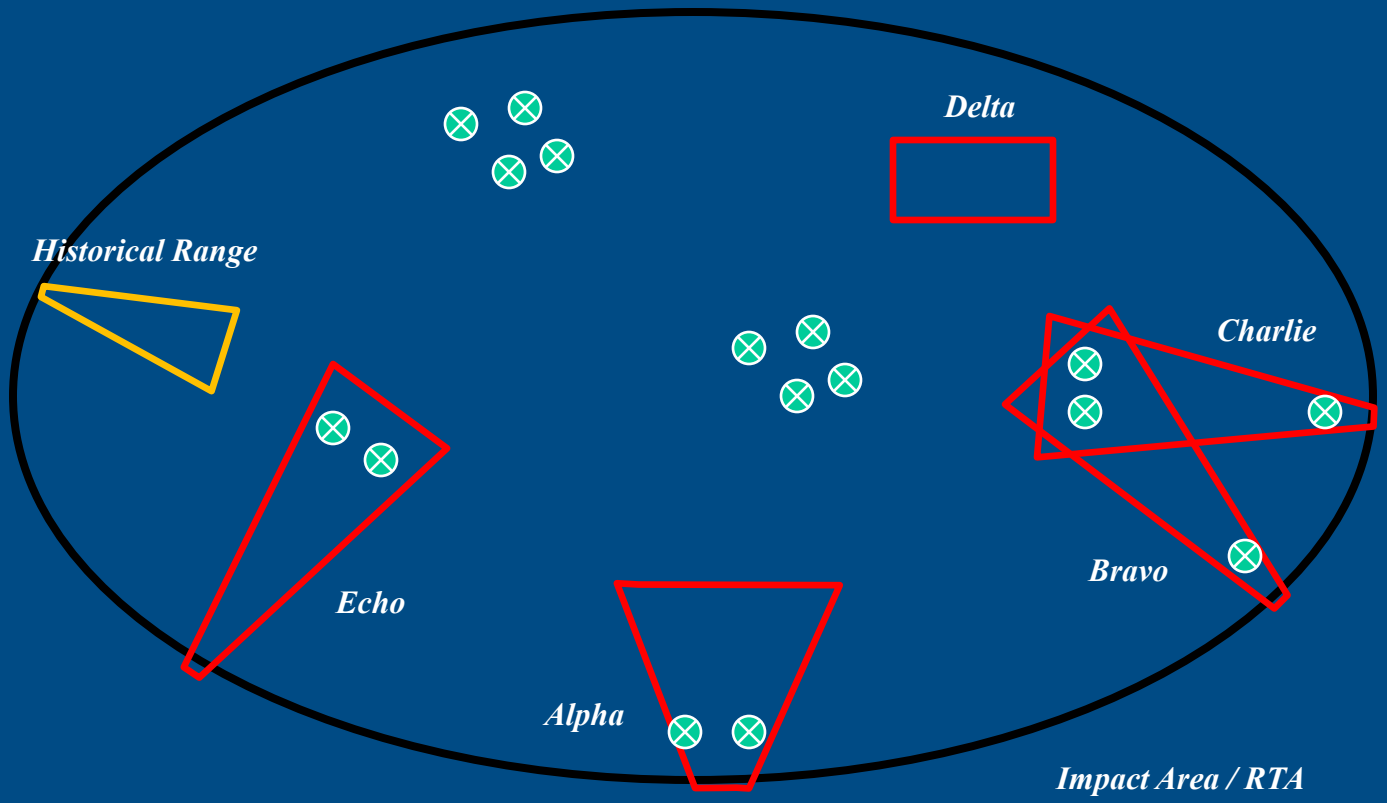
MC Loading Results

Range	Range Area (m^2)	Annual MC Loading (kg/m^2)							
		Period	Begin Use	End Use	HMX	RDX	TNT	Perchlorate	Lead
CURRENT									
Familiarization Range	1.92E+05	D (1977-1988)	1977	1988	1.08E-08	1.15E-07	2.78E-08	6.48E-09	3.24E-09
		E (1989-2009)	1989	2009	1.35E-08	1.44E-07	3.47E-08	8.10E-09	4.05E-09
Average					1.21E-08	1.30E-07	3.13E-08	7.29E-09	3.64E-09

Challenges to MC Loading Process

- Selection / subdivision of MC loading areas
- Expenditure records often incomplete
- Expenditure records typically do not track specific munition to specific target
- Quality of expenditure data is variable
- Use of multiple systems – RFMSS, TRIMS
- EOD ranges – specific munitions items destroyed generally are not tracked, just the donor charges

Range Training Area or Impact Area



- How do you load this area?
  - RTA / impact area?
  - Individual ranges?
  - Specific targets?

Future Efforts

- Trend assessment across installations
- REVA five-year re-evaluation
  - Revise estimates for operational ranges
  - Estimate loading at new operational ranges
- Combine with media-specific screening models to develop MC management toolkit for operational ranges
  - Annual expenditure record updates
  - Determine a munitions loading “breakthrough point”
- Ultimate goal is to provide range managers with ability to anticipate potential off-range MC releases

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Questions?

Backup

MC Calculator Training Timeline

- Based upon subject matter expert opinions
- Takes into account history of wars and conflicts
- 5 Time Periods
  - Period A: 1914-1924 (+40%)
  - Period B: 1925-1937 (Baseline)
  - Period C: 1938-1976 (+50%)
  - Period D: 1977-1988 (+20%)
  - Period E: 1989-Present (+50%)

Breakdown of MCs

Average expended per year across the Marine Corps (training allowance allocations)

- *TNT* *2,356,715 lbs*
- *RDX* *2,162,419 lbs*
- *HMX* *817 lbs*
- *Perchlorate* *33,145 lbs*
- *Lead* *1,090,967 lbs*

**Analysis based upon Marine Corps non-combat expenditure allowance (NCEA) data*

** MIDAS used for explosives loading estimates*